

EFFECTS OF FEEDING ARSENIC AND LEAD UPON THEIR SECRETION IN MILK¹

Information has not been observed on the influence of continuous feeding to cows of relatively low levels of arsenic and lead upon the secretion of these elements in milk. Bovine milk has been reported to contain 0.032 to 0.060 mg/liter of arsenic, with the concentration being somewhat higher in colostrum (5). Milk from one cow late in lactation was found to contain 0.02 mg/kg of lead (1), whereas Kehoe et al. (6) reported the lead content of three milk samples ranging from 0.02 to 0.04 mg/kg.

Both the arsenic and lead contents of cow's milk have been increased by the oral intake of large quantities of these elements. On an area where land and water were contaminated with arsenic, and illness and death of cattle were attributed to arsenic toxicity, milk samples from cows contained from 0.8 to 1.5 mg/liter of arsenic (4). Drenching a lactating heifer daily with 0.3428 g of As_2O_3 as sodium arsenite for three days did not cause an increase in milk arsenic over the predrenching level of 0.23 to 0.27 mg/liter, but did increase the concentration in urine (3). Beginning 11 days later, the animal was drenched with 1.367 g of As_2O_3 daily for three consecutive days, and the arsenic content of milk samples ranged from 0.34 to 0.47 mg/liter during the ensuing four days prior to her death.

A dairy herd consumed two feedings of concentrate contaminated with lead oxide. Milk taken 12 days later from two surviving cows contained 2.26 and 0.15 mg/kg of lead, respectively (8). Milk samples from these two cows taken 122 days after lead feeding contained 0.028 and 0.030 mg/kg of lead, respectively.

This present study was undertaken to determine whether any change in milk levels of arsenic or lead could be detected following continuous feeding of low levels of these elements to lactating cows.

EXPERIMENTAL PROCEDURE

Eight lactating Jersey cows were assigned to four groups of two animals each. They either grazed on millet pasture or were fed chopped millet forage and were offered a concentrate mixture twice daily at the rate of 1 lb per 3 lb of milk produced. Composition of the concentrate mixture expressed as pounds was: soybean meal, 100; ground corn, 300; ground oats, 100; wheat bran, 100; salt, 6; steamed bonemeal, 6. Arsenic and lead were administered by incorporating one-half the daily allowances, as lead arsenate, into 1 lb of concentrate and permitting each cow to consume this before the remainder of the concentrate allowance was offered. Arsenic and lead fed daily

to the cows in milligrams per 100 lb body weight were: Group 1, 0.00 and 0.00; Group 2, 1.17 and 3.23; Group 3, 2.34 and 6.47; Group 4, 4.68 and 12.95, respectively. These levels were fed for 126 days. Body weight of cows fed arsenic and lead ranged from 820 to 1,040 lb.

Before initiation of lead and arsenic feeding, two diagonally positioned quarters were hand-milked and the other two machine-milked. Since no differences were detected in lead or arsenic content of the milk extracted by each method, the animals were milked by machine during the experiment.

With reference to the initiation of arsenic and lead feeding, milk samples for analyses were taken at -5, 0, +1, +3, and +14 days, and subsequently at 14-day intervals, respectively, through the remainder of the 126-day feeding period. Samples were placed in 250-ml polyethylene bottles, cooled in ice water, and kept under refrigeration until analyzed.

Arsenic was determined spectrophotometrically by a minor modification of the Oliver and Funnell method (7). This method utilizes a wet digestion of the sample with HCl, followed by reduction of the arsenic in the mixture and distillation as arsine. Ten-milliliter samples of milk were digested with 15 ml of HCl at 50 C for 1 hr. Under these conditions, excellent recovery of added arsenic was obtained.

Lead was determined by a mono-color dithizone method developed by Cholak and Burkey (2). Ten-milliliter samples of milk were evaporated and charred under an infrared evaporator and finally ashed at 550 C in a muffle furnace.

RESULTS AND DISCUSSION

In all milk samples analyzed, including samples from control cows, concentrations of arsenic and lead were less than 0.05 mg/liter. This was the lower limit for estimation based on a 10-ml sample.

These results obtained on arsenic feeding are in accord with those of Fitch et al. (3), who observed that drenching a heifer with 0.3428 g of As_2O_3 daily for three consecutive days did not cause an increase in arsenic level of the milk. Baxter (1) reported that when less than 3 mg of lead was ingested daily by sheep there was no retention, and within the daily intake range of 2 to 110 mg, absorption apparently was only $1.3 \pm .8\%$. Low absorption and the urinary excretion of lead might account for the observation that no increase was detected in milk lead content at the feeding levels employed.

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ZINC CONTENT OF CERTAIN FEEDS, ASSOCIATED MATERIALS, AND WATER ¹

It has been shown that cattle require zinc (2, 3). However, the practical importance of zinc in ruminant nutrition has not been established and its metabolism is limited.

One of the handicaps in planning nutrition studies is the lack of reliable data on the zinc content of most feeds. Thus, one of the purposes of this paper is to publish data on the zinc content of several feeds and other materials which might be used in future studies. Also, this information will aid in determining the practical importance of zinc in ruminant rations.

Zinc analyses were made by the dithizone procedure developed by Verdier et al. (9). These results are summarized in Table 1. Each of the samples was a composite from one or more different lots of material and thus represents an independent estimate of the zinc content of the ingredient or material. Every sample was analyzed two or more times. The materials chosen for analyses were those which were under consideration for use in zinc nutrition studies or those with which the animals might come in contact.

The 14 milk samples were collected either from the milking machine pail or the bulk tank of herd milk. None of the milk had been in contact with galvanized equipment. The results agree quite closely with values of 3-5 ppm given by Underwood (8) as normal for cow's milk.

Of the feeds for which zinc analyses are presented in this paper, data were given only

for beet pulp, citrus pulp, and corn in a comprehensive compilation published in 1959 for the United States and Canada (1). The average value of 8.9 ppm for beet pulp is more than ten times the 0.3 mg/lb presented in that compilation (1). The 8.9 and 24 ppm for the citrus pulp and yellow corn are somewhat lower and somewhat higher, respectively, than amounts given for these feeds (1). However, the value for the corn grain is in good agreement with analyses reported previously (5-7, 10). Likewise, the average values for soybean oil meal (6, 7, 10), isolated soybean protein (6, 10), washed isolated soybean protein (10), dried egg albumin (egg white) (6), and non-fat dried milk (7) are in good agreement with those reported previously. The dicalcium phosphate used in this study was manufactured by a furnace process and is expected to have a lower zinc content than that made by the wet ash process as used by Zeigler et al. (10).

TABLE 1

Zinc content of certain feed ingredients, associated materials, and water (as-used basis)

| Material | No. samples | Zinc (ppm) | |
|---|-------------|------------|-----|
| | | Range | Avg |
| Milk, whole ^a | 14 | 2.8-4.8 | 3.9 |
| Beet pulp, dried | 7 | 7.4-11.0 | 8.9 |
| Citrus pulp, dried | 4 | 6.5-11.6 | 8.9 |
| Coastal Bermuda grass, dried (Piedmont) ^b | 34 | 23-51 | 32 |
| Coastal Bermuda grass, dried (Coastal plain) ^c | 19 | 12-22 | 16 |
| Corn grain, yellow | 2 | 21-26 | 24 |
| Soybean oil meal (44% protein, solvent-extracted) | 2 | | 62 |

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